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World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse

P2 1358774

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

September 09, 2005

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: *PCT/US04/30116*
FILING DATE: *September 14, 2004*
RELATED PCT APPLICATION NUMBER: *PCT/US04/36446*

By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office

P. R. Grant

P. R. GRANT
Certifying Officer

PCT/US04/30116

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REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No. PCT/US 04/30116

International Filing Date (14.09.04) 14 SEP 2004

Name of receiving Office and "PCT International Application"

PCT INTERNATIONAL APPLICATION RO/US

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 20040005 PCT

Box No. I TITLE OF INVENTION

Method And Apparatus For Through-The-Wall Motion Detection Utilizing CW Radar

Box No. II APPLICANT ☐ This person is also inventor

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEM INTEGRATION INC.
65 Spit Brook Road, NHQ01-719
Nashua, NH 03060
United States of America

Telephone No. 603-885-2643

Facsimile No. 603-885-2167

Teleprinter No.

Applicant's registration No. with the Office

State *(that is, country)* of nationality: United States of America

State *(that is, country)* of residence: United States of America

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

ZEMANY, Paul D.
27 Pulpit Run
Amherst, New Hampshire 03031
United States of America

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: United States of America

State *(that is, country)* of residence: United States of America

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

LONG, Daniel J.
BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEMS INTEGRATION INC.
65 Spit Brook Road, NHQ01-719
Nashua, NH 03060
United States of America

Telephone No. 603-885-2643

Facsimile No. 603-885-2167

Teleprinter No.

Agent's registration No. with the Office 29,404

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Sheet No. ...2...

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

SUTPHIN, Eldon M.
46 Turkey Hill Road
Merrimack, NH 03054
United States of America

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: United States of America

State *(that is, country)* of residence: United States of America

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [x] the United States of America only [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [ ] the United States of America only [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [ ] the United States of America only [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [ ] the United States of America only [ ] the States indicated in the Supplemental Box

[ ] Further applicants and/or (further) inventors are indicated on another continuation sheet.

PCT/US04/30116

Box No. V DESIGNATIONS

The filing of this request **constitutes under Rule 4.9(a), the designation** of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.

However,

☐ DE Germany **is not designated** for any kind of national protection

☐ KR Republic of Korea **is not designated** for any kind of national protection

☐ RU Russian Federation **is not designated** for any kind of national protection

(The check-boxes above may be used to exclude (irrevocably) the designations concerned in order to avoid the ceasing of the effect, under the national law, of an earlier national application from which priority is claimed. See the Notes to Box No. V as to the consequences of such national law provisions in these and certain other States.)

Box No. VI PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application:* regional Office	international application: receiving Office
item (1) ~~20 JAN~~ JANUARY 20 2004	60/537,868	US		
item (2)				
item (3)				

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office)* identified above as:

☐ all items ☒ item (1) ☐ item (2) ☐ item (3) ☐ other, see Supplemental Box

** Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):* . . . .

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*:

ISA / US

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*:

Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII DECLARATIONS

The following **declarations** are contained in Boxes Nos. VIII (i) to (v) *(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration)*:			Number of declarations
☐ Box No. VIII (i)	Declaration as to the identity of the inventor	:	
☒ Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	:	1
☒ Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	:	1
☒ Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America)	:	1
☐ Box No. VIII (v)	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	:	

Box No. VIII (ii) DECLARATION: ENTITLEMENT TO APPLY FOR AND BE GRANTED A PATENT

The declaration must conform to the standardized wording provided for in Section 212; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (ii). If this Box is not used, this sheet should not be included in the request.

Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent (Rules 4.17(ii) and 51*bis*.1(a)(ii)), in a case where the declaration under Rule 4.17(iv) is not appropriate:

In relation to this international application:

BAE Systems Information and Electronic Systems Integration Inc. is entitled to apply for and be granted a patent by virtue of the following:

an assignment from Zemany, Paul D. and Sutphin, Eldon M. to BAE Systems Information and Electronic Systems Integration Inc., dated 07 SEP 2004.

This declaration is made for the purpose of all designations except the designation of the United States.

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (ii)".

PCT/US04/30116

Sheet No. ...5...

Box No. VIII (iii) DECLARATION: ENTITLEMENT TO CLAIM PRIORITY

The declaration must conform to the standardized wording provided for in Section 213; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (iii). If this Box is not used, this sheet should not be included in the request.

Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application specified below, where the applicant is not the applicant who filed the earlier application or where the applicant's name has changed since the filing of the earlier application (Rules 4.17(iii) and 51*bis*.1(a)(iii)):

In relation to this international application:

BAE Systems Information and Electronic Systems Integration Inc., is entitled to claim priority of the earlier application,

Application No. 60/538,868

by virtue of the following:

an assignment from Zemany, Paul D. and Sutphin, Eldon M. to BAE Systems Information and Electronic Systems Integration Inc. dated 07 SEP 2004.

This declaration is made for the purpose of all designations except the designation of the United States.

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iii)".

PCT/US04/30116

Sheet No. 6

Box No. VIII (iv) DECLARATION: INVENTORSHIP (only for the purposes of the designation of the United States of America)

The declaration must conform to the following standardized wording provided for in Section 214; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (iv). If this Box is not used, this sheet should not be included in the request.

Declaration of inventorship (Rules 4.17(iv) and 51*bis*.1(a)(iv)) for the purposes of the designation of the United States of America:

I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/..... (if furnishing declaration pursuant to Rule 26*ter*).

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications: 60/537,868; filed: 20 JAN 2004

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name: ZEMANY, Paul D.

Residence: Amherst, New Hampshire 03031-1510, United States of America
(city and either US state, if applicable, or country)

Mailing Address: 27 Pulpit Run ~~#202~~ P2

Citizenship: United States of America

Inventor's Signature: Paul Zemany
(if not contained in the request, or if declaration is corrected or added under Rule 26*ter* after the filing of the international application. The signature must be that of the inventor, not that of the agent)

Date: Sept. 7 2004
(of signature which is not contained in the request, or of the declaration that is corrected or added under Rule 26*ter* after the filing of the international application)

Name: SUTPHIN, Eldon M.

Residence: Merrimack, New Hampshire 03054, United States of America
(city and either US state, if applicable, or country)

Mailing Address: 46 Turkey Hill Road

Citizenship: United States of America

Inventor's Signature: Eldon M. Sutphin
(if not contained in the request, or if declaration is corrected or added under Rule 26*ter* after the filing of the international application. The signature must be that of the inventor, not that of the agent)

Date: 9-7-04
(of signature which is not contained in the request, or of the declaration that is corrected or added under Rule 26*ter* after the filing of the international application)

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

PCT/US04/30116

Sheet No. 7

Box No. IX CHECK LIST; LANGUAGE OF FILING

This international application **contains:**

(a) **in paper form,** the following number of sheets:

request (including declaration sheets)	:	7
description (excluding sequence listing and/or tables related thereto)	:	8
claims	:	4
abstract	:	1
drawings	:	2
Sub-total number of sheets	:	22
sequence listing	:	
tables related thereto	:	
(for both, actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (c) below)		
Total number of sheets	:	22

(b) ☐ **only in computer readable form** (Section 801(a)(i))
- (i) ☐ sequence listing
- (ii) ☐ tables related thereto

(c) ☐ **also in computer readable form** (Section 801(a)(ii))
- (i) ☐ sequence listing
- (ii) ☐ tables related thereto

Type and number of carriers (diskette, CD-ROM, CD-R or other) on which are contained the
- ☐ sequence listing: .....
- ☐ tables related thereto: .....

(additional copies to be indicated under items 9(ii) and/or 10(ii), in right column)

This international application is **accompanied by** the following item(s) *(mark the applicable check-boxes below and indicate in right column the number of each item):*

		Number of items
1. ☒ fee calculation sheet	:	1
2. ☐ original separate power of attorney	:	
3. ☐ original general power of attorney	:	
4. ☒ copy of general power of attorney; reference number, if any:	:	1
5. ☐ statement explaining lack of signature	:	
6. ☐ priority document(s) identified in Box No. VI as item(s):	:	
7. ☐ translation of international application into *(language)*:	:	
8. ☐ separate indications concerning deposited microorganism or other biological material	:	
9. ☐ sequence listing in computer readable form *(indicate type and number of carriers)*		
(i) ☐ copy submitted for the purposes of international search under Rule 13*ter* only (and not as part of the international application)	:	
(ii) ☐ *(only where check-box (b)(i) or (c)(i) is marked in left column)* additional copies including, where applicable, the copy for the purposes of international search under Rule 13*ter*	:	
(iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listing mentioned in left column	:	
10. ☐ tables in computer readable form related to sequence listing *(indicate type and number of carriers)*		
(i) ☐ copy submitted for the purposes of international search under Section 802(b-*quater*) only (and not as part of the international application)	:	
(ii) ☐ *(only where check-box (b)(ii) or (c)(ii) is marked in left column)* additional copies including, where applicable, the copy for the purposes of international search under Section 802(b-*quater*)	:	
(iii) ☐ together with relevant statement as to the identity of the copy or copies with the tables mentioned in left column	:	
11. ☐ other *(specify)*:	:	

Figure of the drawings which should accompany the abstract: 1

Language of filing of the international application: English

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Daniel J. Long

LONG, Daniel J.
Attorney for Applicant

14 SEPT 2004
DATE

For receiving Office use only

1. Date of actual receipt of the purported international application: DT03 Rec'd PCT/PTO 14 SEP 2004 (14.09.04)

2. Drawings:
☐ received:
☐ not received:

3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:

4. Date of timely receipt of the required corrections under PCT Article 11(2):

5. International Searching Authority (if two or more are competent): ISA / US

6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PCT/US04/38116

PCT

GENERAL POWER OF ATTORNEY

(for several international applications filed under the Patent Cooperation Treaty)

(PCT Rule 90.5)

The undersigned person(s) :
(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

PERKINS, Kevin P.
BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEMS INTEGRATION INC.
65 Spit Brook Road, NHQ01-719
Nashua, NH 03061
United States of America

hereby appoint(s) the following person as: [X] agent [ ] common representative

Name and address
(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

LONG, Daniel J.
BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEMS INTEGRATION INC.
65 Spit Brook Road, NHQ01-719
Nashua, NH 03061
United States of America

to represent the undersigned before

[X] all the competent International Authorities
[ ] the International Searching Authority only
[ ] the International Preliminary Examining Authority only

in connection with any and all international applications filed by the undersigned with the following Office

US as receiving Office

and to make or receive payments on behalf of the undersigned.

Signature(s) *(where there are several persons, each of them must sign; next to each signature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious from reading this power):*

Kevin P. Perkins
SECRETARY
BAE SYSTEMS Information and Electronic Systems Integration Inc.

Date: 26 June 2003

Form PCT/Model of general power of attorney (for several international applications) (July 1992)

PCT *This sheet is not part of and does not count as a sheet of the international application.*

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International Application No. PCT/US 04/30116

Date stamp of the receiving Office 14 SEP 2004

Applicant's or agent's file reference 20040005 PCT

Applicant
BAE Systems Information and Electronic Systems Integration Inc.

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE	300 [T]	300
2. SEARCH FEE	1000 [S]	1000
International search to be carried out by US		
(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)		
3. INTERNATIONAL FILING FEE		
Where items (b) and/or (c) of Box No. IX apply, enter **Sub-total number of sheets** / Where items (b) and (c) of Box No. IX do not apply, enter **Total number of sheets**		
[i1] first 30 sheets	1134 [i1]	1134
[i2] ____ (number of sheets in excess of 30) x ____ (fee per sheet) =	[i2]	
[i3] additional component (only if sequence listing and/or tables related thereto are filed in computer readable form under Section 801(a)(i), or both in that form and on paper, under Section 801(a)(ii)):		
400 x ____ (fee per sheet) =	[i3]	
Add amounts entered at i1, i2 and i3 and enter total at I	1134 [I]	1134
(Applicants from certain States are entitled to a reduction of 75% of the international filing fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the international filing fee.)		
4. FEE FOR PRIORITY DOCUMENT *(if applicable)*	20 [P]	20
5. TOTAL FEES PAYABLE Add amounts entered at T, S, I and P, and enter total in the TOTAL box	1754 TOTAL	2454

MODE OF PAYMENT

- [X] authorization to charge deposit account (see below)
- [ ] postal money order
- [ ] cash
- [ ] coupons
- [ ] cheque
- [ ] bank draft
- [ ] revenue stamps
- [ ] other *(specify):*

AUTHORIZATION TO CHARGE (OR CREDIT) DEPOSIT ACCOUNT

(This mode of payment may not be available at all receiving Offices)

- [X] Authorization to charge the total fees indicated above.
- [X] *(This check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit)* Authorization to charge any deficiency or credit any overpayment in the total fees indicated above.
- [X] Authorization to charge the fee for priority document.

Receiving Office: RO/ US

Deposit Account No.: 190130

Date: 14 SEPT 2004

Name: LONG, Daniel J.

Signature: Daniel J. Long

See Notes to the fee calculation sheet

PCT/US04/30116

METHOD AND APPARATUS FOR THROUGH-THE-WALL MOTION DETECTION UTILIZING CW RADAR

RELATED APPLICATIONS

This Application claims rights under 35 USC 119(e) from US Application Serial No. 60/537,868 filed January 20, 2004, the contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates to through-the-wall sensors and more particularly to the use of CW radar to detect motion of objects behind a wall.

BACKGROUND OF THE INVENTION

Oftentimes it is desirable to be able to detect individuals within, for instance, a burning building or enemy combatants or troops behind a wall. Moreover, in some instances police can utilize through-wall sensing systems to be able to detect the presence of wanted individuals from a position outside the building.

Through-wall sensing can be used in military operations in urban terrain, for homeland security, for law enforcement and for fire departments. The need to sense behind walls is clear. It will be appreciated that the details of the mission and types of walls or obstructions dictate the design of the through-wall sensors.

In the past, ultra-wideband devices have been used as ground penetrating and through-the-wall radars. The difficulty with ultra-wideband approaches is that one has to generate short pulses which requires fairly expensive hardware. A particular difficulty with ultra wide band is that walls have frequency dependent attenuation. This results in a distortion of the return pulses that pass through the wall. This distortion

blurs the pulse making it hard to correlate. Moreover, in ultra-wideband applications one must integrate over multiple pulses in order to obtain enough processing gain to detect objects inside a building. In this regard, in ultra-wideband systems, one has to generate a stream of pulses. The problem with generating streams of pulses is the existence of clutter and with an ultra-wideband pulsed radar, one detects everything within a room. One therefore has to have a means for discriminating clutter from background, which ultra-wideband systems do not do.

What is therefore required is an easily portable, low cost, low power drain, compact unit that can be positioned outside a building that can detect motion of individuals within the building and discriminate against inanimate objects.

SUMMARY OF INVENTION

In order to obtain a through-the-wall motion detector capable of easily detecting a person within a room, is has been found that one can detect these individuals because they are typically in motion. In order to detect individuals behind a wall, the subject invention employs a simple CW radar with a directional antenna. In one embodiment, the transmitter for this CW radar employs a circulator, which is coupled to a directional antenna so that a CW beam is projected through the wall and into the room. Returns from the CW beam arrive at the same antenna and are split off by the circulator. A reduced power replica from the transmitted signal is mixed with the returns from the antenna. Changes in the phase difference between the two signals indicate motion, and thus the presence of an individual behind the wall. In one embodiment, the summing is performed at a mixer, with slight phase differences indicating motion of an object behind a wall. Thus, if there is anything behind the wall that is moving, and recognizing that people normally move, the system will detect them.

In one embodiment, the CW radar transmitter includes a frequency source coupled to a power divider, with one output of the power divider coupled to the circulator and thence to the directional antenna, which may either be a YAGI or may be a planar antenna having plates spaced from a ground plane.

The power divider output is also supplied to the aforementioned mixer that mixes the output signal with radiation returned from behind the wall, with the motion detection including sampling the signal representing the phase difference and applying an adaptive threshold which, when the change in phase difference exceeds a predetermined threshold, the presence of an individual is indicated. Thus if the phase difference change is greater than a predetermined threshold, the presence of an individual is declared. In one embodiment the detection threshold is adaptively determined by a microprocessor and is then used by the microprocessor to declare detections.

The subject system can be made portable and battery powered and can be transported by fire, police, military troops or other individuals conducting a search of a premises. Within seconds one can ascertain whether individuals are within the premises due to the normal motion of the individuals in a room or along a hallway.

It has been found that the phase difference is periodic when the object behind the wall has a constant motion, as when an individual is walking at a constant rate of speed, or is more random when the speed of the object is not constant. In either case, the change in the phase difference between the transmitted signal and the received signal being above a given threshold can be used to trigger an alarm to indicate the presence of an individual or at least some object that is moving.

Thus, in the case of a fire when one does not want to enter a burning building unnecessarily, one can position one or more of these CW radars adjacent the building to

see if there are victims that need rescuing. Likewise, when chasing felons, police may provide such a unit adjacent the outer wall of a building to be able to ascertain if the felon was within the premises.

It will be appreciated that what has been described in one embodiment is a single-frequency CW radar in which a change in the phase difference between the transmitted and received signal is used to indicate the presence of an object in motion behind a wall. It has been found that the system operates irrespective of the type of wall material so that no adjustment need be made based on the type of wall encountered. Moreover, the system automatically discriminates against objects within the room that are stationary, usually inanimate objects. Thus, unlike ultra-wideband radars, the system does not pick up stationary objects such as furniture and the like.

While some frequencies are better than others for wall penetration, it has been found that a signal in the 900 MHz band is optimal for detecting motion behind most walls. However, systems using higher frequencies are effective for longer standoff ranges through lower density walls and lower frequency units are indicated for more dense walls.

In summary, a CW radar is used to detect motion of objects behind a wall by projecting a radar beam through the wall and by measuring the returns from objects behind the wall, with a change in the phase difference between the transmitted and the received CW signals providing an indication of motion behind the wall and thus the presence of an individual. The system may use a microprocessor to set the threshold and declare detections.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the subject invention will be better understood in connection with a Detailed Description, in conjunction with the Drawings, of which:

Figure 1 is a diagrammatic illustration of a single-frequency CW radar having a frequency source, a power divider, a circulator and a mixer, with the circulator being coupled to a directional antenna that directs the CW radar beam into a building and in which a change in the phase difference between returns and the transmitted signal is measured to indicate the presence of an individual behind the wall;

Figure 2 is a diagrammatic illustration of the system of Figure 1 indicating a change in phase difference when the individual behind the wall is moving;

Figure 3 is a graph showing a periodic waveform of the change in phase difference versus time for constant motion;

Figure 4 is a graph of change of phase difference versus time for random motion;

Figure 5 is a graph showing change of phase difference versus time for a stationary object., indicating a straight line on the graph ; and,

Figure 6 is a block diagram of a microprocessor capable of being used in the system of Figure 1 as a motion detector, with the microprocessor including sampling the phase difference signal and providing the output that is used to set an adaptive threshold which is then used to monitor the signal motion detection.

DETAILED DESCRIPTION

Referring now to Figure 1, a CW radar 10 includes a frequency source 12, a power divider 14 and a circulator 16 coupled to an antenna 18. Preferably, the antenna is a directional antenna so as to project all of the energy in a given direction, in this

case through a wall 20, so as to be able to ascertain whether an individual 22 exists behind the wall.

In one embodiment, the radar is a single frequency radar set optimally in one embodiment to 900 MHz, with antenna 18 in one embodiment being a YAGI antenna, with 13 dB forward gain. While a YAGI antenna may be utilized in order to reduce back lobes and yet have a readily portable unit, a flat panel antenna with conductive elements insulated from a ground plane may be used to eliminate back lobes and is lighter and more easily transportable.

As illustrated, one output of power divider 14 is coupled to circulator 16 coupled to a directional antenna 18 that forms a CW beam as illustrated at 24 which penetrates wall 20. Energy reflected by objects behind the wall as illustrated at 26 is detected by antenna 18 is coupled to circulator 16 and thence to a mixer 30, to which is coupled a divided-down sample of the output of frequency source 12. The result is that power divider 14 divides the power of frequency source 12 to provide a phase reference signal to the mixer. Mixer 30 therefore mixes signals on lines 32 and 34 to derive a phase difference or Doppler transmitted on line 36 to a motion detector 40.

It is the function of motion detector 40 to ascertain when a change in phase difference on line 36 exceeds a predetermined threshold. When this occurs, a moving object behind wall 20 is indicated. Motion detector 40 may have a local alarm or display screen, whereas, as indicated by dotted line 42, the output of motion detector 40 may be transmitted by a transmitter 44 via an antenna 46 to a remote location. In one embodiment, the same RF hardware used by the radar is used to also send the detection report to a remote location. This simplifies the design of the system. In another embodiment, the an independent RF transmitter is used to send the detection report.

In this manner, the unit may be set up, for instance, on a tripod near the exterior wall of a building, with the results of the motion detection being detected at a distance from the building, either to protect troops or police from hostile action or to protect monitoring individuals from, for instance, the heat of a fire.

As illustrated in Figure 2, the CW radar 10 projects beam 24 from antenna 18 such that, if individual 22 is moving as illustrated by arrow 48, there is a change in phase difference between beam 24 and returned radiation 26.

As illustrated in Figure 3, for constant motion, when the phase difference change is graphed against time, there is a sinusoidal waveform 54 that results.

As illustrated in Figure 4, if there is random motion of the object behind the wall, then the graph of the phase difference change versus time results in a random curve 56, whereas as illustrated in Figure 5, if the object is stationary, then the phase difference change versus time is flat as illustrated by straight line 58.

Referring now to Figure 6, in one embodiment, motion detector 40 may include a microprocessor 60, which includes as part thereof a sampling circuit that samples and holds the phase-difference signal as illustrated at 62. Changes in the sampled phase difference are calculated and applied to an adaptive threshold unit 64, which outputs a signal on line 66 to a detector 68 that provides a signal when the phase difference change is greater than a threshold T set by adaptable threshold unit 64. When there is a signal on line 70 one can declare that motion has occurred and that there is an individual behind the wall.

What has therefore been provided is an extremely simple system for detecting the presence of an individual behind a wall, which uses a CW radar signal and a unit for detecting a change in the difference in phase between the outgoing transmitted CW signal and the reflected CW signal.

It has been found that this is a very sensitive detector of motion and one for which it is not necessary to integrate pulses or, for instance, to sweep the frequency such as is the case in ultra-wideband applications.

While the present invention has been described in connection with the preferred embodiments of the various figures, it is to be understood that other similar embodiments may be used or modifications or additions may be made to the described embodiment for performing the same function of the present invention without deviating therefrom. Therefore, the present invention should not be limited to any single embodiment, but rather construed in breadth and scope in accordance with the recitation of the appended claims.

WHAT IS CLAIMED IS:

1. A method for detecting the presence of an individual behind a wall, comprising the steps of:

projecting a CW radar signal through a wall;

detecting portions of the CW radar signal returned by an object behind the wall;

determining the phase difference between projected and returned CW radar signals; and,

indicating the presence of an individual when the change in the detected phase difference is above a predetermined threshold, whereby individuals moving behind the wall can be detected.

2. The method of Claim 1, wherein the frequency of the projected signal is constant.

3. The method of Claim 2, wherein the frequency is in the 900 MHz band.

4. The method of Claim 1, wherein the threshold is an adaptive threshold.

5. The method of Claim 1, and further including the step of determining the location of a moving individual behind the wall from peaks in the graph of phase difference versus distance.

6. Apparatus for the detection of a moving individual behind a wall, comprising:

a frequency source;

a power divider coupled to said frequency source for outputting as a first output a CW signal of one predetermined magnitude for forming a radar beam and for outputting as a second output a CW signal of a diminished magnitude;

a circulator coupled to said first output;

an antenna coupled to said circulator for transmitting a CW radar beam towards said wall and for detecting radar returns from objects behind said wall;

a mixer coupled to said second output and said circulator for deriving a signal representing the phase difference between transmitted and returned signals at said antenna; and,

a detector for detecting when there is a change in the phase difference between said transmitted beam and said returns, said phase difference indicating the presence of a moving object behind said wall.

7. The apparatus of Claim 6, wherein said detector includes a processor for sampling the output of said mixer, a threshold detector for ascertaining when said change in phase difference of the output of said mixer exceeds an adaptive threshold, and a motion indicator responsive to the output of said threshold detector for the presence of a moving object behind said wall.

8. The apparatus of Claim 7, wherein the frequency of said transmitted signal is constant, thus to provide a single-frequency CW radar.

9. The apparatus of Claim 8, wherein said single frequency is in the 900 MHz band.

10. The apparatus of Claim 6, wherein said threshold detector is an adaptive threshold detector.

11. The apparatus of Claim 6, wherein said detector detects a moving object behind said wall based on a change in the phase difference between the of the transmitted and returned signals.

12. The apparatus of Claim 11, wherein said phase difference is sensed as a change in the graph of phase difference versus time.

13. The apparatus of Claim 6, wherein said antenna is a directional antenna having minimal back lobes to prevent any motion behind said antenna from affecting said phase difference.

14. The apparatus of Claim 13, wherein said antenna is a YAGI antenna.

15. The apparatus of Claim 13, wherein said antenna is a planar antenna having conductive elements spaced from a ground plane.

16. A system of determining the presence of an individual behind a wall, comprising:

a CW radar having a directional antenna adapted to project CW radar energy through said wall, and detecting returns from objects behind said wall; and,

a phase difference detector for detecting the phase difference between CW energy directed through said wall and energy returned from objects behind said wall, a change in phase difference indicating the presence of a moving object behind said wall.

17. The system of Claim 16, wherein said CW radar operates in the 900 MHz band.

18. The system of Claim 16, wherein said CW radar is a single-frequency radar, whereby no clutter rejection is necessary and no long integration times are required.

19. The system of Claim 16, wherein said directional antenna has minimal back lobes to reject motion behind said antenna so that behind-the-antenna motion is not detected.

ABSTRACT

A CW radar is used to detect motion of objects behind a wall by projecting a radar beam through the wall and by measuring the returns from objects behind the wall, with a change in the phase difference between the transmitted and the received CW signals providing an indication of motion behind the wall and thus the presence of an individual.

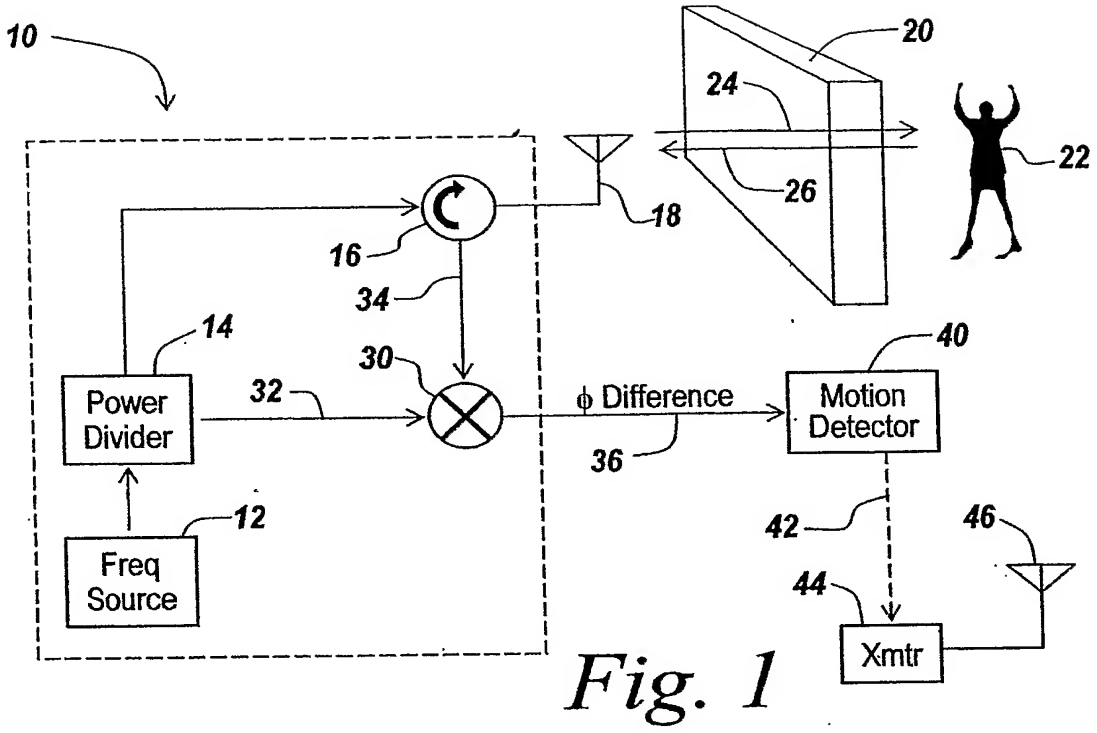
10
20
24
22
26
18
16
34
14
30
32
Power Divider
ϕ Difference
40
Motion Detector
36
42
46
44
12
Freq Source
Xmtr

Fig. 1

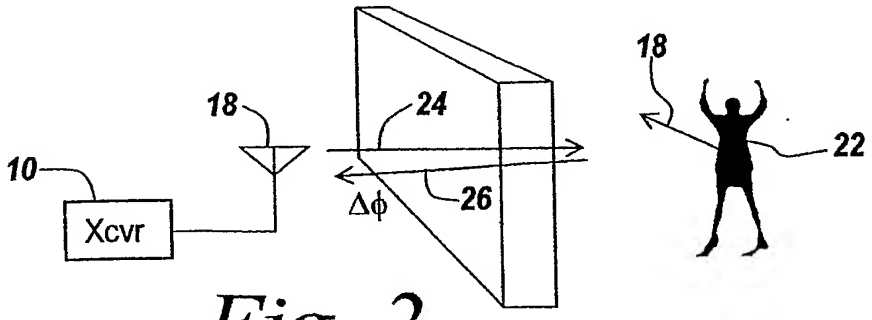
18
24
18
22
10
26
Δϕ
Xcvr

Fig. 2

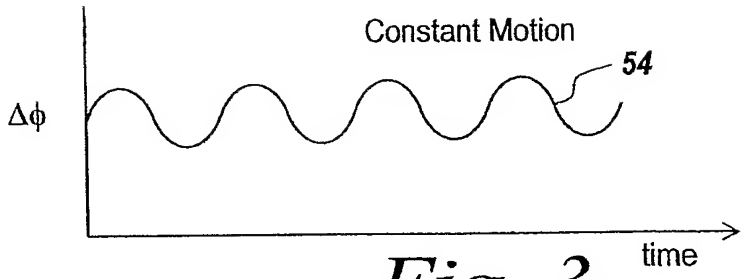

Fig. 3

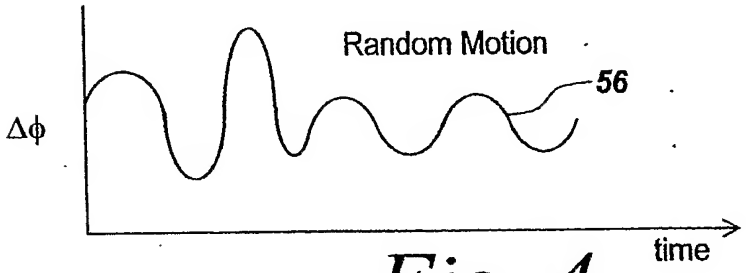

Fig. 4

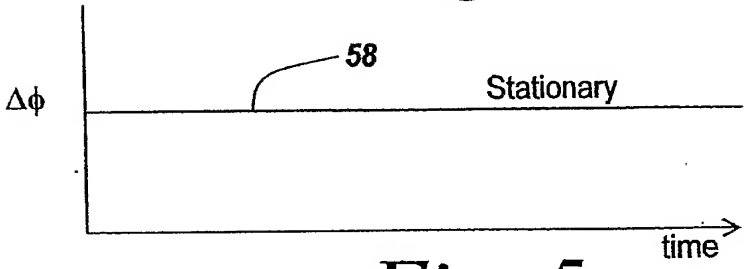

Fig. 5

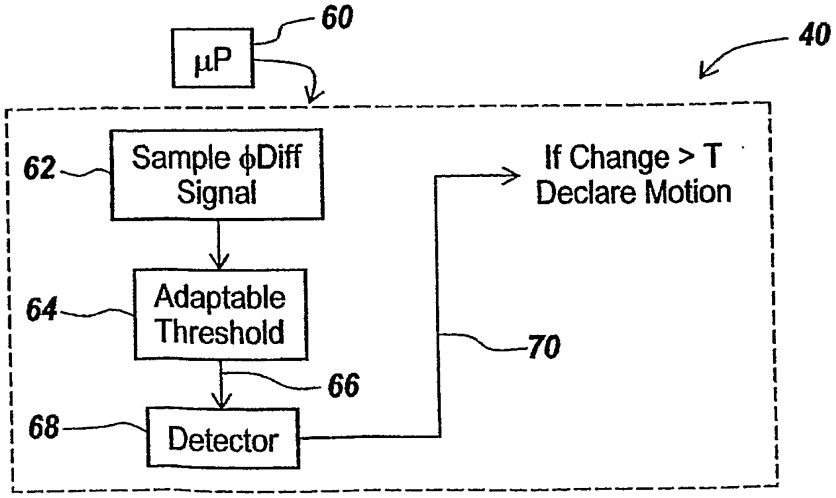

Fig. 6

PATENT COOPERATION TREATY

From the RECEIVING OFFICE

To:

DANIEL J. LONG
BAE SYSTEMS INFORMATION AND
ELECTRONIC
SYSTEMS INTEGRATION INC.
65 SPIT BROOK ROAD, NHQ01-719
NASHUA, NEW HAMPSHIRE 03060

PCT

NOTIFICATION CONCERNING PAYMENT OF PRESCRIBED FEES

(PCT Rules 14, 15 and 16 and Administrative Instructions, Sections 102*bis*(c), 304, 323(b), 707(b) and 803)

Date of mailing *(day/month/year)*	21 Jun 2005
Applicant's or agent's file reference: 20040005 PCT	**PAYMENT DUE** see item 3 for time limits

International application No.	International filing date/Date of receipt *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2004/030116	14 Sep 2004	20 Jan 2004

Applicant: BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEM INTEGRATION INC.

1. The applicant is hereby notified that this receiving Office has received:

[X] **the payment** of all the prescribed fees, and [ ] **an overpayment**, which will be refunded in due course.

[ ] **no or insufficient payment** of the prescribed fees and the applicant is hereby **invited to pay the balance due**, as summarized under item 2, within the time limit(s) indicated under item 3.

2. **Fees and payment calculation:**

2,454.00	–	2,454.00	=	0.00
Total fees payable		Amount paid		Balance

[ ] The details of the calculation are given in the Annex.

3. **Time limit(s) for payment and amount(s) payable (Rules 14.1, 15.4 and 16.1(f)):**

[ ] within ONE MONTH from the date of receipt of the international application (**for the transmittal fee** (if any), **the search fee** and **the international filing fee**). The amount payable for each fee is the amount applicable on the date of receipt of the international application.

[ ] within 16 MONTHS from the priority date (only for the fee for priority document). The applicant's attention is drawn to the fact that the request made by the applicant under Rule 17.1(b) will be considered not to have been made unless the fee is paid within that time limit.

4. Additional observations *(if necessary)*:

[ ] The search copy will not be transmitted to the International Searching Authority until the search fee is paid (therefore the start of the international search will be delayed) (Rule 23.1(a) and (b)).

Name and mailing address of the receiving Office	Authorized officer
Mail Stop PCT, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 703-305-3230	Catherine Williams Telephone No. 703-305-3677

Form PCT/RO/102 (January 2004)

ANNEX TO FORM PCT/RO/102
CALCULATION OF THE PRESCRIBED FEES

International application No.
PCT/US2004/030116

[T] Transmittal Fee

Prescribed amount:		300.00 [T]	
Amount paid:	–	300.00	[x] correct amount
Balance:	=	0.00	[ ] overpayment
			[ ] balance due

[S] Search Fee

Prescribed amount:		1,000.00 [S]	
Amount paid:	–	1,000.00	[x] correct amount
Balance:	=	0.00	[ ] overpayment
			[ ] balance due

[I] International Filing Fee

Fixed amount for first 30 sheets: 1,134.00 [i1]

0 (Number of sheets in excess of 30) x 12.00 (Fee per sheet) = 0.00 [i2]

Additional component: . . . 400 x 0.00 (Fee per sheet) = 0.00 [i3]

Reduction where the international application is filed *(See PCT Applicant's Guide, Volume I, General Part, for details on the availability of this reduction)*:

using the PCT-EASY software: – 0.00 [r]

or

in electronic form where the text of the description, claims and abstract **is not** in character coded format: – 0.00 [r]

or

in electronic form where the text of the description, claims and abstract is in character coded format: – 0.00 [r]

Sub-total: = 1,134.00 [i1+i2+i3-r]

Prescribed total amount *(The amount to be entered at I is the sub-total entered at (i1+i2+i3-r), except where the applicant is (or all applicants are) entitled to a reduction of 75%, in which case the amount to be entered at I is 25% of the sub-total (i1+i2+i3-r); certain applicants from certain States are entitled to a reduction of 75% of the international filing fee; see Notes to the Fee Calculation Sheet as annexed to the Request Form, PCT/RO/101, for details)*: = 1,134.00 [I]

Amount paid:	–	1,134.00	[x] correct amount
Balance:	=	0.00	[ ] overpayment
			[ ] balance due

[P] Fee for Priority Document

Prescribed amount:		20.00 [P]	
Amount paid:	–	20.00	[x] correct amount
Balance:	=	0.00	[ ] overpayment
			[ ] balance due

PATENT COOPERATION TREATY

From the RECEIVING OFFICE

To:
DANIEL J. LONG
BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEMS INTEGRATION INC.
65 SPIT BROOK ROAD, NHQ01-719
NASHUA, NEW HAMPSHIRE 03060

PCT

NOTIFICATION OF THE INTERNATIONAL APPLICATION NUMBER AND OF THE INTERNATIONAL FILING DATE

(PCT Rule 20.5(c))

Date of mailing *(day/month/year)*	21 Jun 2005
Applicant's or agent's file reference: 20040005 PCT	IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2004/030116	14 Sep 2004	20 Jan 2004

Applicant: BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEM INTEGRATION INC.

Title of the invention: METHOD AND APPARATUS FOR THROUGH-THE-WALL MOTION DETECTION UTILIZING CW RADAR

1. The applicant is hereby notified that the international application has been accorded the international application number and the international filing date indicated above.

2. The applicant is further notified that the record copy of the international application:

[X] was transmitted to the International Bureau on 21 Jun 2005.

[ ] has not yet been transmitted to the International Bureau for the reason indicated below and a copy of this notification has been sent to the International Bureau*:

[ ] because the necessary national security clearance has not yet been obtained.

[ ] because *(reason to be specified)*:

* The International Bureau monitors the transmittal of the record copy by the receiving Office and will notify the applicant (with Form PCT/IB/301) of its receipt. Should the record copy not have been received by the expiration of 14 months from the priority date, the International Bureau will notify the applicant (Rule 22.1(c)).

3. FOREIGN TRANSMITTAL LICENSE INFORMATION — Completed by: CW

[ ] Additional license for foreign transmittal not required. This subject matter is covered by a license already granted or the equivalent U.S. national application. Refer to that license for information concerning its scope.

[ ] License for foreign transmittal not required. 37 CFR. 5.11(e)(1) or 37 CFR 5.11(e)(2). However, a license may be required for additional subject matter. See 37 CFR 5.15(b).

[X] Foreign transmittal license granted. 35 U.S.C. 184; 37 CFR 5.11 on 21 Oct 2004 (date):

[ ] 37 CFR 5.15(a) [X] 37 CFR 5.15(b)

Name and mailing address of the receiving Office	Authorized officer
Mail Stop PCT, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450	Catherine Williams CW
Facsimile No. 703-305-3230	Telephone No. 703-305-3677

Form PCT/RO/105 (July 1992)

PATENT COOPERATION TREATY

From the RECEIVING OFFICE

To:

DANIEL J. LONG
BAE SYSTEMS INFORMATION AND
ELECTRONIC
SYSTEMS INTEGRATION INC.
65 SPIT BROOK ROAD, NHQ01-719
NASHUA, NEW HAMPSHIRE 03060

PCT

NOTIFICATION REGARDING CERTAIN CORRECTIONS MADE *EX OFFICIO*

(PCT Administrative Instructions, Section 327)

	Date of mailing *(day/month/year)*: 21 Jun 2005
Applicant's or agent's file reference: 20040005 PCT	**REPLY DUE**: NONE. However, see paragraph 3 below
International application No.: PCT/US2004/030116	International filing date *(day/month/year)*: 14 Sep 2004
Applicant: BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEM INTEGRATION INC.	

1. The applicant is hereby notified that this receiving Office has corrected formal defects in the international application *ex officio*, as shown on the attached copy of:

- [x] the request, sheet No.: 3
- [ ] the description, sheet No.: _____
- [ ] the claims, sheet No.: _____
- [ ] the drawings, sheet No.: _____
- [ ] other *(specify)*: _____

2. If the applicant agrees with these corrections, no further action is required in this regard.

3. **In case of disagreement** with these corrections, the applicant should promply inform this receiving Office accordingly.

Name and mailing address of the receiving Office Mail Stop PCT, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 703-305-3230	Authorized officer Catherine Williams Telephone No. 703-305-3677

Form PCT/RO/146 (July 1992; reprint January 2004)

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:

DANIEL J. LONG
BAE SYSTEMS INFORMATION AND
ELECTRONIC
SYSTEMS INTEGRATION INC.
65 SPIT BROOK ROAD, NHQ01-719
NASHUA, NEW HAMPSHIRE 03060

PCT

NOTIFICATION OF RECEIPT
OF SEARCH COPY

(PCT Rule 25.1)

Date of mailing *(day/month/year)*	21 Jun 2005
Applicant's or agent's file reference: 20040005 PCT	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2004/030116	14 Sep 2004	20 Jan 2004

Applicant

BAE SYSTEMS INFORMATION AND ELECTRONIC SYSTEM INTEGRATION INC.

1. **Where the International Searching Authority and the receiving Office are not the same Office:**
The applicant is hereby notified that the search copy of the international application was received by this International Searching Authority on the date indicated below.

Where the International Searching Authority and the receiving Office are the same Office:
The applicant is hereby notified that the search copy of the international application was received on the date indicated below.

21 Jun 2005 *(date of receipt).*

2. ☐ The search copy was accompanied by a nucleotide and/or amino acid sequence listing or tables related thereto in computer readable form.

3. **Time limit for establishment of international search report and written opinion of the International Searching Authority**
The applicant is informed that the time limit for establishing the international search report and the written opinion of the International Searching Authority is three months from the date of receipt indicated above or nine months from the priority date, whichever time limit expires later (Rules 42.1 and 43*bis*.1(a)).

4. A copy of this notification has been sent to the International Bureau and, where the first sentence of paragraph 1 applies, to the receiving Office.

Name and mailing address of the ISA/	Authorized officer
Mail Stop PCT, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 703-305-3230	Catherine Williams Telephone No. 703-305-3677

Form PCT/ISA/202 (January 2004)